FORM PTO-1390 (REV. 9-2001) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: CNF-002

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/018219

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB00/02350	16 JUNE 2000	18 JUNE 1999

TITLE OF INVENTION: IMPROVED PUMP

APPLICANT(S) FOR DO/EO/US: Hector Filippus Alexander Van Drentham Susman

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [X] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). **unexecuted**
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	JC07 Rec'd PCT/PTO 18 DEC 2001 ATTORNEY'S DOCKET NUMBER
10/018219	PCT/GB00/02350	CNF-002

21. ☒ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	73 - 20 =	53	x **$18.00**	$ 954.00	
Independent claims	4 - 3 =	1	x **$84.00**	$ 84.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1,038.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$	
SUBTOTAL =				$ 1,038.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 1,928.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 1,928.00	
				Amount to be refunded:	$
				charged:	$

a. ☒ A check in the amount of $ 1,928.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1980 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

H.T. Than
SIGNATURE

H.T. Than
NAME

38,632
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of: H. SUSMAN

Application No.: not yet assigned
(International Application No. PCT/GB00/02350)

Group Art Unit: Not assigned

Filed: Concurrently herewith
(International Application filed 16 JUNE 2000)

Examiner: Not assigned

For: IMPROVED PUMP

Attorney Docket No.: CNF-002

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231
BOX PCT

Sir:

IN THE CLAIMS:

Please cancel claims 74-77 without prejudice. Please amend the claims as indicated in the Version with Markings to Show Changes Made submitted herewith, where subject matter to be added is underlined and subject matter to be deleted is in brackets. A Clean Version of the Amended Claims is also submitted herewith.

REMARKS

The claims of this application are being amended prior to examination in order to facilitate the Examiner's review and consideration of the application. No new matter has been added. The claims currently pending in the above captioned application are claims 1-73.

Dated: December 18, 2001

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Version with Markings to Show Changes Made

3. (Amended) A pump as claimed in [either of claims] claim 1 [or 2], wherein the means for varying the volume of the chamber is controlled by relative rotation of first and second bodies of the pump.

7. (Amended) A pump as claimed in [any of claims] claim 3 [to 6], wherein the chamber is provided within the second body.

9. (Amended) A pump as claimed in [any of claims] claim 3 [to 8], wherein the first and second bodies are each of an elongate form.

10. (Amended) A pump as claimed in [any of claims] claim 3 [to 9], wherein the second body comprises a rotor.

19. (Amended) A pump as claimed in claim 18, wherein the means for varying the volume of the chamber includes at least one piston supported by the [first] second body and biased by means towards the [second] first body.

22. (Amended) A pump as claimed in [any of claims] claim 1 [to 21], wherein the inlet includes a first one-way valve.

24. (Amended) A pump as claimed in [any of claims] claim 1 [to 23], wherein the outlet includes a second one-way valve.

26. (Amended) A pump as claimed in [any of claims] claim 12 [to 14], wherein there is provided at least one pair of pistons supported by the second body and radially opposing one another relative thereto.

28. (Amended) A pump as claimed in [either of claims] claim 26 [or 27], wherein there are provided a plurality of pairs of pistons, each pair being longitudinally spaced from an adjacent pair along the second body.

29. (Amended) A pump as claimed in [any of claims] claim 12 [to 14 or claims 26 to 28], wherein [the/]each piston includes a rotatable member free to rotate at least along a longitudinal axis with respect to the rotor.

30. (Amended) A pump as claimed in [any of claims] claim 12 [to 14 or claims 26 to 29], wherein [the/]each piston includes a piston member.

34. (Amended) A pump as claimed in [any of claims] claim 1 [to 33], wherein the means for varying the volume of the chamber is driven by drive means.

43. (Amended) A pump as claimed in claim 10 [or 11], wherein the rotor is provided with at least two piston apertures which are disposed substantially opposite one another, each of the piston apertures being provided with a respective piston.

44. (Amended) A pump as claimed in claim [43] 26 [when dependent upon claim 11], wherein each piston has a slot, hole or gap to allow fluid to flow through the piston from the chamber, which fluid flow assists in lubricating contacting surfaces of the piston(s) and the stator and the piston(s) and the rotor.

49. (Amended) A plurality of pumps according to [any of claims] claim 1 [to 48], so arranged as to be operatively connected with one another.

54. (Amended) A pump as claimed in [any of claims] claim 11 [1 to 47], wherein at least one first vent hole is provided at a predetermined position through the stator, allowing any pressure differential across the stator to be [equalised] equalized, and held to the pressure external to the pump.

63. (Amended) A pump as claimed in [either of claims] claim 61 [or 62], wherein the filter means carries an end plate.

64. (Amended) A pump as claimed in [any of claims] claim 61 [to 63], wherein the filter means is formed from a sheet form mesh material.

65. (Amended) A pump as claimed in [any of claims] claim 61 [to 64], wherein the means for cleaning the filter means is driven by means by which the pump is driven.

66. (Amended) A pump as claimed in [any of claims] claim 61 [to 65], wherein the pump provides a chamber having a volume, an inlet communicating with the chamber, and further an outlet from the chamber, and means for varying the volume of the chamber.

70. (Amended) A pump as claimed in [any of claims] claim 68 [61 to 69], wherein the means for cleaning comprises at least one blade, knife or scraper substantially rigidly attached to the stator.

72. (Amended) A pump as claimed in [any of claims] claim 61 [to 71], wherein the filter means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

73. (Amended) A pump as claimed in [either of claims] claim 70 [or 71], wherein the blade(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylkentone, metal, copper alloys and stainless steel.

Claims 74-77 have been canceled.

Clean Version of the Amended Claims

3. (Amended) A pump as claimed in claim 1, wherein the means for varying the volume of the chamber is controlled by relative rotation of first and second bodies of the pump.

7. (Amended) A pump as claimed in claim 3, wherein the chamber is provided within the second body.

9. (Amended) A pump as claimed in claim 3, wherein the first and second bodies are each of an elongate form.

9. (Amended) A pump as claimed in claim 3, wherein the second body comprises a rotor.

19. (Amended) A pump as claimed in claim 18, wherein the means for varying the volume of the chamber includes at least one piston supported by the second body and biased by means towards the first body.

22. (Amended) A pump as claimed in claim 1, wherein the inlet includes a first one-way valve.

24. (Amended) A pump as claimed in claim 1, wherein the outlet includes a second one-way valve.

26. (Amended) A pump as claimed in claim 12, wherein there is provided at least one pair of pistons supported by the second body and radially opposing one another relative thereto.

28. (Amended) A pump as claimed in claim 26, wherein there are provided a plurality of pairs of pistons, each pair being longitudinally spaced from an adjacent pair along the second body.

29. (Amended) A pump as claimed in claim 12, wherein each piston includes a rotatable member free to rotate at least along a longitudinal axis with respect to the rotor.

30. (Amended) A pump as claimed in claim 12, wherein each piston includes a piston member.

34. (Amended) A pump as claimed in claim 1, wherein the means for varying the volume of the chamber is driven by drive means.

43. (Amended) A pump as claimed in claim 10, wherein the rotor is provided with at least two piston apertures which are disposed substantially opposite one another, each of the piston apertures being provided with a respective piston.

44. (Amended) A pump as claimed in claim 26, wherein each piston has a slot, hole or gap to allow fluid to flow through the piston from the chamber, which fluid flow assists in lubricating contacting surfaces of the piston(s) and the stator and the piston(s) and the rotor.

49. (Amended) A plurality of pumps according to claim 1, so arranged as to be operatively
connected with one another.

54. (Amended) A pump as claimed in claim 11, wherein at least one first vent hole is provided at a predetermined position through the stator, allowing any pressure differential across the stator to be equalized, and held to the pressure external to the pump.

63. (Amended) A pump as claimed in claim 61, wherein the filter means carries an end plate.

64. (Amended) A pump as claimed in claim 61, wherein the filter means is formed from a sheet form mesh material.

65. (Amended) A pump as claimed in claim 61, wherein the means for cleaning the filter means is driven by means by which the pump is driven.

66. (Amended) A pump as claimed in claim 61, wherein the pump provides a chamber having a volume, an inlet communicating with the chamber, and further an outlet from the chamber, and means for varying the volume of the chamber.

70. (Amended) A pump as claimed in claim 68, wherein the means for cleaning comprises at least one blade, knife or scraper substantially rigidly attached to the stator.

72. (Amended) A pump as claimed in claim 61, wherein the filter means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

73. (Amended) A pump as claimed in claim 70, wherein the blade(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylkentone, metal, copper alloys and stainless steel.

IMPROVED PUMP

Background of the Invention

This invention relates to pumps, and in particular, though not exclusively, to a pump for use in the oil/gas and/or chemical industries. A pump of the present invention is particularly suitable for use in a method of "artificial lift" in an oil/gas well.

In many oil wells the oil does not have enough pressure to flow all the way up the tubing to the surface. The produced water and oil has to be lifted up the tubing to the surface by one of several methods, normally called artificial lift. Even with a flowing oil well, as more fluids are removed from the subsurface reservoir, the pressure on the remaining oil decreases until it no longer flows up the tubing to the surface.

A common artificial lift apparatus is the sucker-rod pump system. The sucker-rod pump or rod-pumping system uses a downhole rod pump, a surface pumping unit, and a sucker-rod string that runs down the well to connect them. The sucker-rod pump has a standing valve and travelling valve. The travelling valve reciprocates up and down while the standing valve remains stationary.

The sucker-rod pump system suffers from a number of problems. Fluid pound is a problem caused when the produced liquid is pumped faster than it is flowing into the well. Gas enters the pump and the pump can be damaged. Gas lock is an extreme case of fluid pound. Gas

accumulates in the pump and prevents the pump from working.

An artificial lift method used on wells that produce large volumes of liquid is gas lift. In a gas lift well, a compressed inert gas called lift gas (usually natural gas that was produced from the well) is injected into the annulus in the well between the casing and tubing. Gas lift valves - pressure valves that open and close - are spaced along the tubing string. They allow the gas to flow into the tubing, where it dissolves in the liquid and also forms bubbles. This lightens the liquid and, along with the expanding bubbles, forces the produced liquid up the tubing string to the surface where the gas can be recycled. The advantages of gas lift is that there is very little surface equipment and few moving parts. Gas lift is a very inexpensive technique when many wells are serviced by only one central compressor facility. However, it is effective only in relatively shallow wells. Offshore oil wells and crooked or deviated wells that need artificial lift are usually completed with gas lift. Gas lift is either continuous or intermittent (periodically on and off) for wells with low production.

Artificial lift may also be provided by means of a submersible electrical pump. A submersible electrical pump normally uses an electric motor that drives a centrifugal pump with a series of rotating blades on a shaft located on the bottom of the tubing. An armoured electrical cable runs up the well, strapped to the tubing string. Electricity is supplied by a transformer on the surface.

The electric motor has a variable speed that can be adjusted for lifting different volumes of liquids. Submersible electrical pumps are used for lifting large volumes of liquid and for crooked and deviated wells. A gas separator is often used on the bottom of the pump to prevent gas from forming in the pump and decreasing the pump's efficiency. Prior art electrical pumps are therefore coupled to a turbine or the like and provide axial flow of fluid.

A hydraulic pump may also be used to provide artificial lift. A known hydraulic pump is identical to a sucker-rod pump except it is driven by hydraulic pressure from a fluid pumped down the well. It uses two reciprocating pumps. One pump on the surface injects a high pressure power oil (usually crude oil from a storage tank) down a tubing string in the well. A reciprocating hydraulic motor on the bottom of the tubing is driven by the power oil. It is coupled to a pump, similar to a sucker-rod pump, and located below the fluid level in the well. The motor drives the pump, which lifts both the spent power oil and the produced fluid from the well up another tubing string. The power fluid causes the upstroke and the release of pressure causes the downstroke. It is called a parallel-free pump. In another variation, (casing-free pump), the power fluid is pumped down a tubing string and the produced liquid is pumped up the casing-tubing annulus. The stroke in a hydraulic pump is very similar to a sucker-rod pump stroke except it is shorter.

Hydraulic pumps can be either fixed (screwed onto the tubing string) or free (pumped up and down the well). They can also be either open (with downhole mixing of power and produced fluids) or closed (with no mixing). Most are free and open.

Known pumps used in artificial lift methods suffer from a number of problems/disadvantages - e.g. low efficiency (hydraulic efficiency).

It is an object of at least one aspect of the present invention to obviate or mitigate one or more of the aforementioned problems/disadvantages in the prior art.

It is a further object of at least one embodiment of the present invention to provide a pump which provides a positive displacement of a predetermined volume of well production fluid for each operative cycle of the pump - in contra-distinction to pumps of the prior art which provide axial flow of well production fluid.

Summary of the Invention

According to a first aspect of the present invention there is provided a pump providing a chamber having a volume, an inlet to the chamber, an outlet from the chamber, and means for varying the volume of the chamber.

The pump may be adapted to be used downhole - e.g. in an oil/gas well.

The means for varying the volume of the chamber may be controlled by relative rotation of first and second bodies of the pump.

In a first embodiment the second body may be provided within the first body and may be substantially concentric therewith.

In a second embodiment the second body may be provided within the first body and may be substantially eccentric therewith.

The chamber may be provided within the second body, and preferably longitudinally within the second body.

The first and second bodies may each be of an elongate form.

The second body may comprise a rotor.

The first body may comprise a stator.

The means for varying the volume of the chamber may include at least one piston supported by the second body and biased by means towards the first body.

A first end of the/each piston may communicate with the chamber while a second end of the/each piston may be urged by biassing means into contact with an inner surface of the stator.

Relative rotation of the first and second bodies may cause movement of the piston(s) thereby varying the volume of the chamber.

In the first embodiment the first body may have a substantially elliptical (or oval) internal bore. Further the second body may provide a substantially cylindrical or optionally elliptical outer surface.

Alternatively, the first body may have a substantially cylindrical internal bore and the second body may provide

a substantially elliptical outer surface.

Further the means for varying the volume of the chamber may include at least one piston supported by the first body and biased by means towards the second body.

In the second embodiment the first body may have a substantially cylindrical internal bore. Further the second body may provide a substantially cylindrical outer surface.

The inlet may include a first one-way valve and perhaps one or more back-up valves.

The outlet may include a second one-way valve and perhaps one or more back-up valves.

There may be provided at least one pair of pistons supported by, and preferably provided substantially within, the second body and radially opposing one another relative thereto.

There may be provided a plurality of pair of pistons, each pair being longitudinally spaced from an adjacent pair along the second body.

The/each piston may include a rotatable member free to rotate at least along a longitudinal axis with respect to the rotor.

The/each piston may also include a piston member.

The piston member may include a concave portion capable of receiving at least a portion of the rotatable member.

In one embodiment each rotatable member may be in the form of a sphere, e.g. a ball bearing.

In an alternative embodiment each rotatable member may be in the form of a cylinder, e.g. a rod (roller).

The means for varying the volume of the chamber may be driven by any suitable drive means - e.g. hydraulic, pneumatic, or electric.

The drive means may include a drive shaft for rotating the rotor, in use.

Preferably the rotor may be provided with at least one seal (or bushing) for sealing engagement with the stator.

Preferably the/each seal is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the piston member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel. The piston(s) may be hollow, spherical, cylindrical, cuboid or polygonal.

Preferably the rotatable member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper, alloys and stainless steel. The rotatable member(s) may be hollow, spherical or cylindrical.

Preferably the/each biassing means, e.g. spring(s), is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the rotor is provided with at least two

piston apertures which are disposed substantially opposite one another, each of the piston apertures being provided with a respective piston.

Preferably each piston may have a slot, hole or gap to allow fluid to flow through the piston from the chamber, i.e. rotor channel, which fluid flow may assist in lubricating contacting surfaces of the piston(s) and the stator and the piston(s) and the rotor.

In a preferred embodiment the pump may comprise/include 24 pistons and respective biassing means, wherein each piston and biassing means may work individually in series, or in parallel with one another. This feature is particularly beneficial in seeking to allow continuous flow of drive fluid through the pump, thereby, for example, obviating or mitigating hydraulic hose vibration.

The rotor may be provided with a plurality of pistons arranged in pairs, each aperture of each pair being substantially opposite to the other.

In a preferred embodiment one biassing means may be used for each piston of a pair by traversing the chamber/ rotor channel, but not cutting off fluid flow through the chamber.

In a preferred embodiment one or more one valves may be used for the inlet of the pump, and one or more one way valves may be used for the outlet of the pump, allowing fluid flow to travel through the chamber.

According to a second aspect of the present invention,

there is provided a plurality of pumps according to the first aspect so arranged as to be operating connected with one another.

The pumps may operate in phase with one another and may not be separated by a one-way valve(s).

Alternatively, the pumps may be arranged so that, in use the pumps operate out of phase with one another. Thus two pumps with two chambers each may be connected 90 degrees out of phase with one another. Alternatively, two pumps each with four chambers may be connected 45 degrees out of phase. Arrangements such as these help to ensure a smooth output and inhibit drive motor stalling.

At least one first vent hole may be manufactured at a desired position through the stator, allowing any pressure differential across the stator to be equalised, and held to the pressure external to the pump.

The rotor may be provided within at least one bearing pack which may include at least one radial bearing and at least one thrust bearing. The bearing pack may include at least one seal at a fluid upstream end and at least one seal at a fluid downstream section end of the bearing pack(s).

At least one second vent hole may be manufactured at a desired position through a bearing housing, allowing any pressure differential across the bearing pack(s)to be equalised, and held to the pressure external to the pump.

The rotor may be connected to a drive by means of a spline, hex, polygon or other similar coupling.

According to a third aspect of the present invention there is provided a well completion including at least one pump, the at least one pump providing a chamber having a volume, an inlet to the chamber, and an outlet from the chamber, and means for varying the volume of the chamber.

According to a fourth aspect of the present invention there is provided a method of artificial lift within an oil/gas well comprising the steps of:

lowering a pump to a desired position within a borehole of a well, the pump providing a chamber having a volume, an inlet to the chamber, an outlet from the chamber and means for varying the volume of the chamber;

driving the pump by varying the volume of the chamber thereby pumping well fluids downstream through the pump and a tubing of the well.

Herein the term upstream is intended to mean closer to the well source, and downstream is intended to mean nearer to surface.

According to a fifth aspect of the present invention there is provided a pump including an inlet, a filter means associated with the inlet, and means for cleaning the filter means.

The filter means may comprise a substantially cylindrical body and may carry an end plate.

The filter means may be formed from a sheet form mesh material.

The means for cleaning the filter means may be driven

by means by which the pump is driven.

The pump may provide a chamber having a volume, an inlet communicating with the chamber, and further an outlet from the chamber, and means for varying the volume of the chamber.

The means for varying the volume of the chamber may be controlled by relative rotation of first and second bodies of the pump.

The first and second bodies may comprise a stator and a rotor, respectively.

In one embodiment, the filter means may be rigidly attached to the rotor so as to rotate therewith.

The means for cleaning may comprise at least one blade, knife or scraper, to be known hereinbelow as the blade(s), rigidly attached to the stator.

The blade(s) may have a serrated edge or surface which, when coming into contact with the filter means, in use, may allow any debris or contamination build up on the filter means to be removed.

Preferably the filter means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Preferably the blade(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Brief description of the Drawings

Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, which are:

Fig 1 a detailed sectional side view of a pump according to a first embodiment of the present invention;

Fig 2 a detailed sectional view along line A-A of Fig 1 in a first position;

Fig 3 a detailed sectional view along line A-A of Fig 1 in a second position;

Fig 4 a schematic sectional side view of a well completion including a pump according to Fig 1; and

Fig 5 a detailed sectional view from the top of a second embodiment of the present invention.

Detailed Description of the Drawings

Referring initially to Figs 1 to 3 there is shown a pump, generally designated 5, according to a first embodiment of the present invention. The pump 5 provides a chamber 10, having a volume V, an inlet 15 to the chamber 10 an outlet 20 from the chamber 10, and means for varying the volume V of the chamber 10, which will be described in greater detail hereafter.

The pump 5 includes filter means 25 associated with the inlet 15 and means for cleaning the filter means, which will also be described in greater detail hereinafter. The

filter means 25 are rigidly attached to the rotor 35.

The pump 5 of this embodiment is adapted to be used downhole - e.g. in an oil/gas well.

The means for varying the volume V of the chamber 10 is controlled by relative rotation of first and second elongate bodies - comprising a stator 30 and a rotor 35 respectively - of the pump. In this embodiment the rotor 35 is provided within the stator 30, substantially concentric therewith. The chamber 10 is provided longitudinally within the rotor 35. The means for varying the volume V of the chamber 10 includes a plurality of pistons 40 supported by the rotor 35 and biassed towards an inner surface of the stator 30.

A first end of each piston 40 communicates with the chamber 10 while a second end of each piston 40 is urged by biassing means such as a coiled spring 45 into contact with the inner surface of the stator 30.

As can be seen from Figs 2 and 3, the stator 30 has a substantially elliptical or oval internal bore. Further the rotor 35 provides a substantially cylindrical outer surface.

Relative rotation of the stator 30 and rotor 35 thus causes movement of the pistons 40 thereby varying the volume V of the chamber 10.

The inlet 15 includes a first one-way valve 50 while, the outlet 20 includes a second one-way valve 55.

As can be seen from Figs 1 to 3, there are provided a plurality of pairs of pistons 40 supported by and provided

substantially within the rotor 35, and radially opposing one another relative thereto. Each pair of pistons 40 are longitudinally spaced from an adjacent pair along the rotor 35.

Each piston 40 includes a rotatable member 60 free to rotate at least longitudinally with respect to a piston member 65. The piston member 65 includes a concave portion 69 capable of receiving at least a portion of the rotatable member 60. In this embodiment each rotatable member 60 is in the form of a sphere, e.g. a ball bearing.

In an alternative embodiment each rotatable member 60 may be in the form of a cylinder, e.g. a rod (roller).

The means for varying the volume V of the chamber 10 are driven by any suitable drive means - e.g. hydraulic, pneumatic, or electric. The drive means includes a drive shaft 70 for rotating the rotor 35 in use.

The rotor 35 is provided with at least one seal (or bushing) 75 for sealing engagement with the stator 30. The /each seal 75 is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

Further the piston members 65 are made from a material selected from the group consisting of plastics, polyethylethylketone, metal, copper alloys and stainless steel.

Yet further the rotable members 60 are made from a material selected from the group consisting of plastics

materials, polyethylethylketone, metal, copper alloys and stainless steel.

Further also springs 45 are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

The rotor 35 is provided with pairs of piston apertures 80, each of the piston apertures 80 being provided with a respective piston 40.

As can be seen from Figure 1 each piston member 65 has a slot, hole or gap to allow fluid to bleed through the piston member from the chamber 10, i.e. channel, which fluid flow assists in lubricating contacting surfaces body of each piston 40 and the stator 30.

In this embodiment the pump 10 may comprise/include 24 pistons 40 and 12 coiled springs 45. This feature is particularly beneficial in seeking to allow continuous flow of drive fluid through the pump 5, thereby, for example, obviating or mitigating hydraulic hose vibration.

The rotor 35 is provided with a plurality of pistons 40 arranged in pairs, each aperture 80 of each pair being substantially opposite to the other.

Further, one coiled spring 45 is used for each piston 40 of a pair by traversing the chamber 10 - but not cutting off fluid flow through the chamber 10.

In a modified embodiment more than one one way valve may be provided at inlet 15 of the pump 10, and more than one one way valve may be provided at the outlet 20 of the

pump 10 allowing fluid flow to travel through the chamber 10.

It will be appreciated that a plurality of pumps 5 according to the invention may be so arranged as to be operated connected with one another.

For example, the pumps may be arranged so that in use, the pumps operate out of phase with one another. Thus two pumps with two chambers each may be connected 90 degrees out of phase with one another. Alternatively, two pumps each with four chambers may be connected 45 degrees out of phase. Arrangements such as these to help to ensure a smooth output and inhibit motor stalling.

Referring to Fig. 1 at least one first vent hole 85 is provided through the stator 30, allowing any pressure differential across the stator 30 to be equalised, and held to the pressure external to the pump 10.

The rotor 35 is provided within a bearing pack 90 held within a bearing housing 95, the pack 90 including at least one radial bearing and at least one thrust bearing 90, and at least one seal 100 upstream and at least one seal 105 downstream of the bearing pack 90.

The bearing pack 90 includes at least one second vent hole 110 provided through the bearing housing 95, allowing any pressure differential across the radial bearing(s) and thrust bearing(s) to be equalised, and held to the pressure external to the pump 10.

The rotor 35 is connected to a drive means including drive shaft 70 by a coupling 115, e.g. a spline, hex or

other similar coupling provided with a drive housing 116.

Referring to Fig 1 the means for cleaning the filter means 25 are driven by means by which the pump 5 is driven. The filter means 25 comprise a substantially cylindrical body made of a sheet mesh, and carries an end plate 160. The cleaning means comprise a pair of elongate blades 120 rigidly attached to the stator 30. The blades 120 may have a serrated edge or surface which, when coming into contact with the filter means 25, in use, allow any debris or contamination build up on the filter means 25 to be removed.

The filter means 25 is made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

The blades 120 are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

In use, the rotor 35 is rotated via the drive means including driveshaft 70. Well fluid is caused to pass through the filter 25 while the rotor 35 rotates. The blades 120 which may be stationary relative to the filter means 25 constantly clean the filter means 25. The filtered fluid then passes through the inlet 15 and first one way valve 50.

The fluid then enters the chamber 10 (aided by a possible positive differential surrounding/external

pressure) when the pistons 40, in their maximum extended positions, are shown in a non-power position, as shown in Figure 3. As the rotor 35 is driven through 90 degrees, as in Figure 2, the pistons 40 are forced inwards due to the internal elliptical shape of the stator 30 thus compressing the fluid within the chamber 10. The resulting pressure change within the chamber 10 forces the first one way valve 50 shut and the second one way valve 55 open allowing fluid to flow through the chamber 10 within the bearing housing 95 and to surface. This process is cyclical and occurs twice per revolution.

It is envisaged that the embodiment of the invention described above, which may represent a 3⅛" diameter of pump 5, may supply fluid at an approximate working pressure of 5000 PSI and a flowrate of approximately 23.16 litres per minute which is equal to 210 US barrels per day.

For the disclosed 24 piston embodiment the flow rate Q may be calculated from:

$$Q = \text{NUMBER OF PISTONS} \times \text{CYCLES PER REVOLUTION OF ROTOR} \times \left[\frac{\pi}{4} \times [\text{DIAMETER OF CHANNEL}]^2 \right] \times \text{STROKE DISTANCE BALL BEARINGS MOVE}$$

Referring to Fig 4 there is shown a well completion, generally designated 125, comprising a borehole 130 having a casing 135. Within the casing 135 there is provided a production tubing 140, and between the casing 135 and tubing 140 one or more packers 145.

When it is desired to provide artificial lift a pump 5 is lowered down within tubing 140 to a desired position on coiled tubing 150 or the like.

The pump 5 may be driven via power line 155 which may be a hydraulic or electric line suitable for driving the drive means to which the rotor 35 is connected. In use, therefore, well produce is delivered to the surface via the coiled tubing 150.

Referring now to Fig. 5 there is shown a pump, generally designated 5', according to a second embodiment of the present invention. Like parts of the pump 5' are identified by the same numerals as for the pump 5 of the first embodiment, but suffixed "'".

In the pump 5' the first elongate body comprises a stator 30' and the second elongate body comprises a rotor 35'. As be seen from Fig. 5 the rotor 35' is provided within the stator 30' but longitudinally eccentric relative thereto. Further, the stator 30' has a substantially cylindrical inner bore, while the rotor 35' also has a substantially cylindrical outer surface.

The stator 30' has a central axis "S'", while the rotor has a central axis "R'".

By this arrangement relative rotations of the rotor 35' and stator 30' causes movement of the piston(s) 40 thereby causing the volume V' of the chamber 10' to be varied.

It will be appreciated that the embodiments of the invention hereinbefore described are given by way of

example only, and are not meant to limit the scope thereof in any way.

Particular advantages of the disclosed embodiment will be appreciated. For example the disclosed pump is completely mechanical and is a metal based device.

CLAIMS

1. A pump providing a chamber having a volume, an inlet to the chamber, an outlet from the chamber, and means for varying the volume of the chamber.

2. A pump as claimed in claim 1, wherein the pump is adapted to be used downhole such as in an oil/gas well.

3. A pump as claimed in either of claims 1 or 2, wherein the means for varying the volume of the chamber is controlled by relative rotation of first and second bodies of the pump.

4. A pump as claimed in claim 3, wherein the second body is provided within the first body.

5. A pump as claimed in claim 4, wherein the first and second bodies are substantially concentric one with the other.

6. A pump as claimed in claim 4, wherein the first and second bodies are substantially eccentric relative to one another.

7. A pump as claimed in any of claims 3 to 6, wherein the chamber is provided within the second body.

8. A pump as claimed in claim 7, wherein the chamber is provided substantially longitudinally within the second body.

9. A pump as claimed in any of claims 3 to 8, wherein the first and second bodies are each of an elongate form.

10. A pump as claimed in any of claims 3 to 9, wherein the second body comprises a rotor.

11. A pump as claimed in claim 10, wherein the first body comprises a stator.

12. A pump as claimed in claim 11, wherein the means for varying the volume of the chamber includes at least one piston supported by the second body and biased by means towards the first body.

13. A pump as claimed in claim 12, wherein a first end of the/each piston communicates with the chamber and a second end of the/each piston is urged by biassing means into contact with an inner surface of the stator.

14. A pump as claimed in claim 13, wherein relative rotation of the first and second bodies causes movement of the piston(s) thereby varying the volume of the chamber.

15. A pump as claimed in claim 4, wherein the first body has a substantially elliptical or oval internal bore.

16. A pump as claimed in claim 15, wherein the second body is provided with a substantially cylindrical or elliptical outer surface.

17. A pump as claimed in claim 4, wherein the first body has a substantially cylindrical internal bore.

18. A pump as claimed in claim 17, wherein the second body is provided with a substantially elliptical outer surface.

19. A pump as claimed in claim 18, wherein the means for varying the volume of the chamber includes at least one piston supported by the first body and biased by means towards the second body.

20. A pump as claimed in claim 6, wherein the first body has a substantially cylindrical internal bore.

21. A pump as claimed in claim 20, wherein the second body is provided with a substantially cylindrical outer surface.

22. A pump as claimed in any of claims 1 to 21, wherein the inlet includes a first one-way valve.

23. A pump as claimed in claim 22, wherein the inlet also includes one or more back-up valves.

24. A pump as claimed in any of claims 1 to 23, wherein the outlet includes a second one-way valve.

25. A pump as claimed in claim 24, wherein the outlet also includes one or more back-up valves.

26. A pump as claimed in any of claims 12 to 14, wherein there is provided at least one pair of pistons supported by the second body and radially opposing one another relative thereto.

27. A pump as claimed in claim 26, wherein the at least one pair of piston is provided substantially within the second body.

28. A pump as claimed in either of claims 26 or 27, wherein there are provided a plurality of pair of pistons, each pair being longitudinally spaced from an adjacent pair along the second body.

29. A pump as claimed in any of claims 12 to 14 or claims 26 to 28, wherein the/each piston includes a rotatable member free to rotate at least along a longitudinal axis with respect to the rotor.

30. A pump as claimed in any of claims 12 to 14 or claims 26 to 29, wherein the/each piston includes a piston member.

31. A pump as claimed in claim 30, wherein the piston member includes a concave portion capable of receiving at least a portion of the rotatable member.

32. A pump as claimed in claim 31, wherein each rotatable member is in the form of a sphere.

33. A pump as claimed in claim 31, wherein each rotatable member is in the form of a cylinder.

34. A pump as claimed in any of claims 1 to 33, wherein the means for varying the volume of the chamber is driven by drive means.

35. A pump as claimed in claim 34, wherein the drive means includes a drive shaft for rotating the rotor, in use.

36. A pump as claimed in claim 11, wherein the rotor is provided with at least one seal or bushing for sealing engagement with the stator.

37. A pump as claimed in claim 36, wherein the/each seal is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

38. A pump as claimed in claim 30, wherein the piston member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

39. A pump as claimed in claim 12, wherein the piston(s) is hollow, spherical, cylindrical, cuboid or polygonal.

40. A pump as claimed in claim 29, wherein the rotatable member(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper, alloys and stainless steel.

41. A pump as claimed in claim 29, wherein the rotatable member(s) is hollow, spherical or cylindrical.

42. A pump as claimed in claim 13, wherein the/each biassing means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

43. A pump as claimed in claim 10 or 11, wherein the rotor is provided with at least two piston apertures which are disposed substantially opposite one another, each of the piston apertures being provided with a respective piston.

44. A pump as claimed in claim 43 when dependent upon claim 11, wherein each piston has a slot, hole or gap to allow fluid to flow through the piston from the chamber, which fluid flow assists in lubricating contacting surfaces of the piston(s) and the stator and the piston(s) and the rotor.

45. A pump as claimed in claim 1, wherein the pump comprises or includes a plurality pistons and respective biassing means, wherein each piston and biassing means works individually in series or in parallel with one another.

46. A pump as claimed in claim 44, wherein the rotor is provided with a plurality of pistons arranged in pairs, each aperture of each pair being substantially opposite to the other.

47. A pump as claimed in claim 46, wherein one biassing means is used for each piston of a pair by traversing the chamber but not cutting off fluid flow through the chamber.

48. A pump as claimed in claim 1, wherein one or more one valves are used for the inlet of the pump and one or more one way valves are used for the outlet of the pump allowing fluid flow to travel through the chamber.

49. A plurality of pumps according any of claims 1 to 48, so arranged as to be operatively connected with one another.

50. A plurality of pumps as claimed in claim 49, wherein the pumps operate substantially in phase with one another and are not separated by a one-way valve(s).

51. A plurality of pumps as claimed in claim 49, wherein the pumps are arranged so that, in use, the pumps operate out of phase with one another.

52. A plurality of pumps as claimed in claim 51, wherein two pumps with two chambers are each connected 90 degrees out of phase with one another.

53. A plurality of pumps as claimed in claim 48, wherein two pumps each with four chambers are connected 45 degrees out of phase.

54. A pump as claimed in any of claims 1 to 47, wherein at least one first vent hole is provided at a predetermined position through the stator, allowing any pressure differential across the stator to be equalised, and held to the pressure external to the pump.

55. A pump as claimed in claim 54, wherein the rotor is provided within at least one bearing pack which includes at least one radial bearing and at least one thrust bearing.

56. A pump as claimed in claim 55, wherein the bearing pack includes at least one seal at a fluid upstream end and at least one seal at a fluid downstream section end of the bearing pack(s).

57. A pump as claimed in claim 55, wherein at least one second vent hole is provided at a predetermined position through a bearing housing, allowing any pressure differential across the bearing pack(s)to be equalised, and held to the pressure external to the pump.

58. A pump as claimed in claim 10, wherein the rotor is connected to a drive by means of a spline, hex, polygon or other similar coupling.

59. A well completion including at least one pump, the at least one pump providing a chamber having a volume, an inlet to the chamber, and an outlet from the chamber, and means for varying the volume of the chamber.

60. A method of artificial lift within an oil/gas well comprising the steps of:

lowering a pump to a desired position within a borehole of a well, the pump providing a chamber

having a volume, an inlet to the chamber, an outlet from the chamber and means for varying the volume of the chamber;

driving the pump so varying the volume of the chamber thereby pumping well fluids downstream through the pump and a tubing of the well.

61. A pump including an inlet, a filter means associated with the inlet, and means for cleaning the filter means.

62. A pump as claimed in claim 61, wherein the filter means comprises a substantially cylindrical body.

63. A pump as claimed in either of claims 61 or 62, wherein the filter means carries an end plate.

64. A pump as claimed in any of claims 61 to 63, wherein the filter means is formed from a sheet form mesh material.

65. A pump as claimed in any of claims 61 to 64, wherein the means for cleaning the filter means is driven by means by which the pump is driven.

66. A pump as claimed in any of claims 61 to 65, wherein the pump provides a chamber having a volume, an inlet communicating with the chamber, and further an outlet from the chamber, and means for varying the volume of the chamber.

67. A pump as claimed in claim 66, wherein the means for varying the volume of the chamber is controlled by relative rotation of first and second bodies of the pump.

68. A pump as claimed in claim 67, wherein the first and second bodies comprise a stator and a rotor, respectively.

69. A pump as claimed in claim 68, wherein the filter means is rigidly attached to the rotor so as to rotate therewith.

70. A pump as claimed in any of claims 61 to 69, wherein the means for cleaning comprise at least one blade, knife or scraper substantially rigidly attached to the stator.

71. A pump as claimed in claim 70, wherein the blade(s) has a serrated edge or surface which, when coming into contact with the filter means, in use, act to allow any debris or contamination build up on the filter means to be removed.

72. A pump as claimed in any of claims 61 to 71, wherein the filter means is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

73. A pump as claimed in either of claims 70 or 71, wherein the blade(s) is/are made from a material selected from the group consisting of plastics materials, polyethylethylketone, metal, copper alloys and stainless steel.

74. A pump as hereinbefore described with reference to Figs. 1 and 2 and to Figures 4 and 5.

75. An assembly of a plurality of pumps so arranged as to be operatively connected together as hereinbefore described.

76. A well completion as hereinbefore described with reference to Figure 3.

77. A method of artificial lift within an oil/gas well as hereinbefore described with reference to Fig. 3.

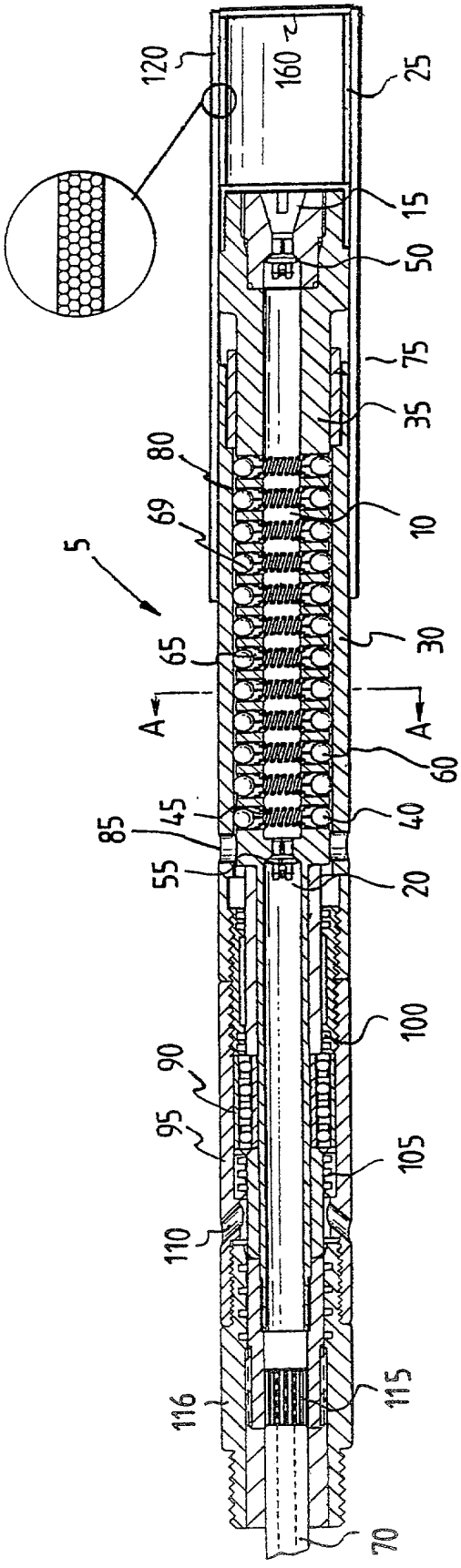

Fig. 1

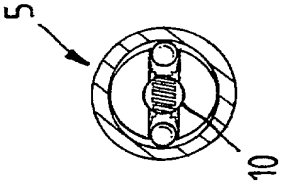

Fig. 3

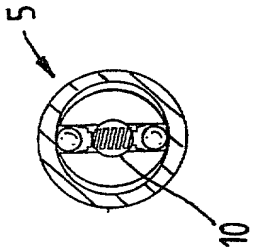

Fig. 2

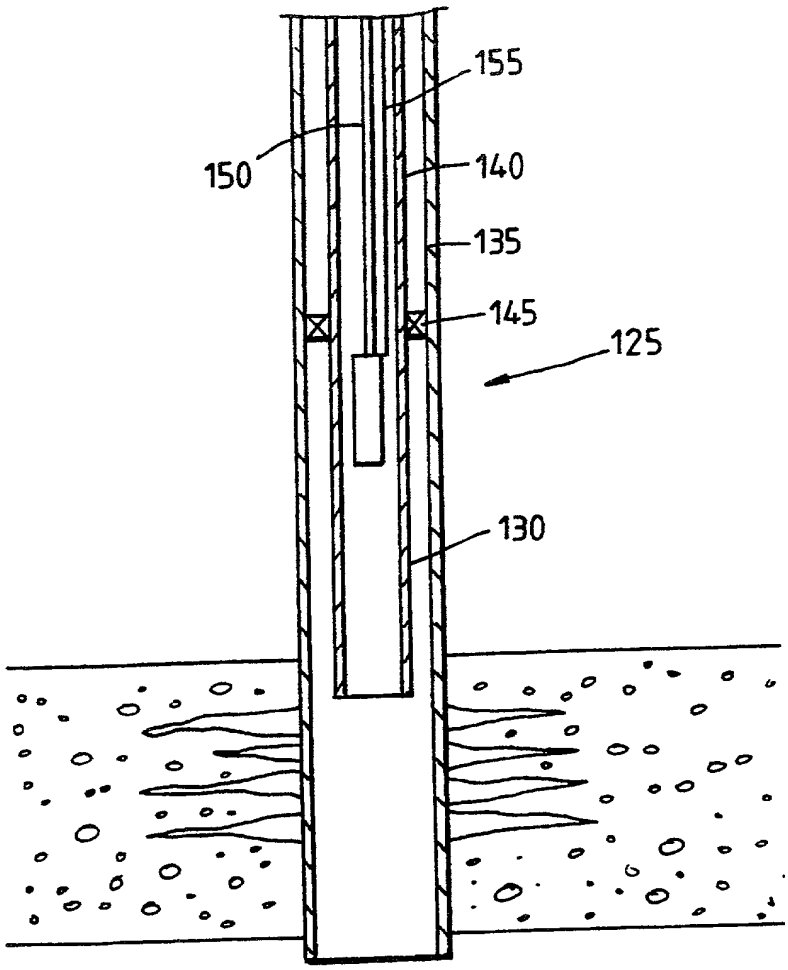

Fig. 4

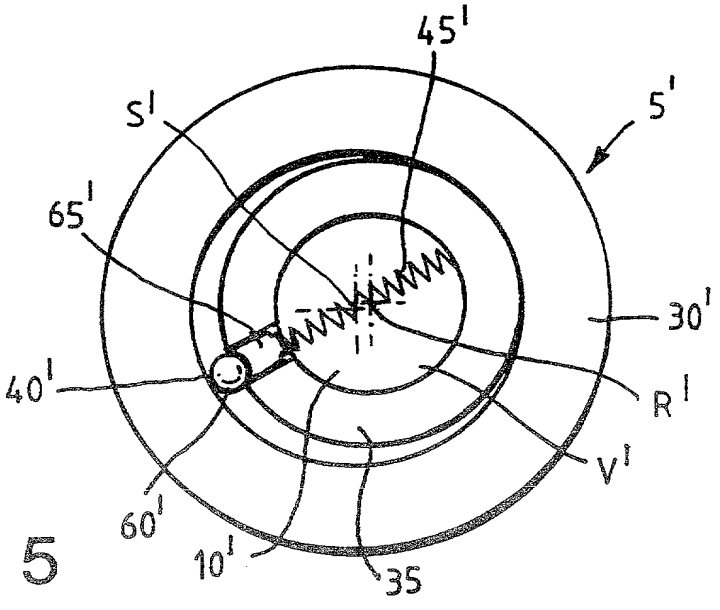

Fig. 5

DECLARATION
AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that·

My residence, post office address and citizenship are as stated below at 201 et seq. underneath my name.

I believe I am the original, first and sole inventor if only one name is listed at 201 below, or an original, first and joint inventor if plural names are listed at 201 et seq below, of the subject matter which is claimed and for which a patent is sought on the invention entitled

IMPROVED PUMP

and for which a patent application

☐ is attached hereto and includes amendment(s) filed on *(if applicable)*

☐ was filed in the United States on as Application No _____ with amendment(s) filed on *(if applicable)*

☒ was filed as PCT international Application No **PCT/GB00/02350** on **16 June 2000** and was amended under PCT Article 19 on *(if applicable)*

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment referred to above

☒ acknowledge the duty to disclose information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

☒ I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed

EARLIEST FOREIGN APPLICATION(S), IF ANY, FILED PRIOR TO THE FILING DATE OF THE APPLICATION			
APPLICATION NUMBER	COUNTRY	DATE OF FILING (day, month, year)	PRIORITY CLAIMED
99 14 120.9	**GREAT BRITAIN**	**18 JUNE 1999**	YES ☒

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below

APPLICATION NUMBER	FILING DATE

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1 56 which became available between the filing date of the prior application and the national or PCT international filing date of this application

APPLICATION SERIAL NO	FILING DATE	STATUS		
		PATENTED	PENDING	ABANDONED

POWER OF ATTORNEY As a named inventor, I hereby appoint H T Than (Reg No 38,632), whose address is Sutton Executive Center, 3201 New Mexico Avenue, N.W., Suite 350, Washington, D C 20016, my attorney, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith

SEND CORRESPONDENCE TO:	H.T. Than, Attorney-at-law 3201 New Mexico Avenue, N.W., Suite 350 Washington, D.C. 20016	DIRECT TELEPHONE CALLS TO: (202) 363-2620

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202	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
203	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
204	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
205	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
206	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 11 JAN 02.	DATE	DATE
SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE	DATE	DATE